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ARTICLE

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ABSTRACT

Underworking (i.e. shirking) and overworking of employees can have detrimental effects for the individual and the organisation. We develop a computational model to investigate how work structure, specifically the way in which managers distribute work tasks amongst employees, impacts work intensity and working time. The model draws on theories from economics, psychology and management, and on empirical observations. The simulations show that when managers correctly estimate task difficulty, but undervalue the employee's competence, opportunities for shirking are provided due to longer deadlines. Similarly, if managers overvalue the employee's competence, they set tighter deadlines leading to overwork. If task difficulty is misjudged, initially only influence on employee working time is observed. However, it gradually generates competence misjudgements, indirectly impacting the employee's effort level. An interaction between competence misjudgement and task uncertainty slows the manager's ability to correctly estimate employee competence and prolongs initial competence misjudgements. The study highlights the importance of applying dynamic modelling methods, which allows for testing theory assumptions *in silico*, generating new hypotheses and offers a foundation for future research.

Practitioner summary: A computational model was developed to investigate how the structure of work allocation influences opportunities for shirking and overworking by employees. The paper demonstrates how dynamic modelling can be used to explain workplace phenomena and develop new hypotheses for further research.

Abbreviations: KSA: knowledge, skills, attitudes; MIT: motivation intensity theory

Introduction

A century ago, Frederick Taylor (1911) predicted that elimination of soldiering (i.e. working slowly) would have profound effects in the forms of lowering production costs, enlarging the market, reducing unemployment and poverty, ensuring higher wages, and decreasing working hours. Yet, shirking is still a phenomenon, which every single working person has been guilty of, at one time or another. The opposite, overworking, is also more common than we would wish for. Previous research, with the use of game theory, experiments, or quantitative studies in organisations, stressed the importance of factors such as monitoring practices, payment scheme, type of work, organisational structure, personal engagement, or employee

empowerment (for review see Antosz 2018). In this study, we investigate how the structure of work organisation is sufficient to create opportunities for shirking and overworking. We combine results of empirical studies and assumptions from several theoretical perspectives in a single mechanism, programmed as a computational model. Agent-based modelling was chosen because it draws attention to the emergent character of shirking and overworking, which can originate from interactions between managers and employees. Simulations of the model allow us to assess *in silico* the impact of (1) adverse selection, (2) task uncertainty, and (3) interactions between those two on work intensity and working time of employees. The following section discusses the theoretical foundations of the model.

Theoretical background

Work intensity and working time

Evaluating work performance is a difficult task. Theoretical approaches guiding work performance evaluation have mainly focussed on the amount of effort exerted by the employee[1] (Albanese and van Fleet 1985; Demski and Feltham 1978; Gachter and Fehr 2000), although some more recent studies highlight the importance of time spent on performing work tasks (Paulsen 2014). In fact, the two approaches considering the amount of effort and the amount of working time are related, given that effort has been conceptualised as having three main characteristics: direction, intensity and duration (Kanfer 1990). Direction of effort concerns the activity in which the individual is engaged, e.g. a work task or a non-work task. Intensity of effort defines the level of engagement (i.e. work intensity). The temporal attribute refers to the amount of time a person is engaged in the activity (i.e. working time). A cautious reader would surely point out that there is a relationship between work intensity and working time. Indeed, *ceteris paribus*, exerting more effort results in decreasing the amount of time necessary for completing a task. However, since an employee can at most exert 100% of effort, there is a limit to the reduction of working time.

This article focuses on the concepts of work intensity and working time, as these two represent relatively easy to measure, historically applied and legally meaningful dimensions of work performance. An employee cannot be dismissed on the basis of low work motivation, because it is not the employee's legal obligation to be motivated. However, a lawful dismissal can occur if an employee did not work during the contracted hours. The importance of those concepts was also confirmed in an exploratory, empirical study carried out by the authors (Antosz and Verhagen 2020). Work intensity and working time are usually in some way present in legislation governing employment. For instance, in Polish regulations work effort is related to the basic obligation of an employee to perform work conscientiously and carefully and to comply with the instructions of superiors related to the work (art. 100 §1 of the Labour Code; Gersdorf, Raczkowski and Rączka 2014). Interestingly, an obligation of conscientiousness entails that the employer customises work to the abilities of the employee (Baran 2016; Jaskowski and Maniewska 2016). Working time on the other hand, according to the Polish Labour Code, is not solely comprised of time of effective work. It refers to the time when an employee is at the disposal of his employer to perform work duties. This specific legal setting governs the structure of work organisation where the employee sells to his employer his ability to perform work tasks in a contracted amount of time and it is the employer's responsibility to plan an individual employee's work to use that time to the fullest.[2] The remaining part of the article focuses on the effects of this particular way of organising labour practices on the opportunities to shirk and/or overwork.

Shirking and overworking

Work intensity and working time are two dimensions in which aberrations can occur. Aberrations take place when an employee's actions deviate from the manager's expectations. They can take two forms: shirking or overworking. Individual in-depth interviews with managers and white-collar lower-level employees showed that discrepancies between existing legislation and managerial expectations occur (Antosz 2018; Antosz and Verhagen 2020). Most importantly, managers want their employees to complete work tasks.[3] Yet, the law obliges them to coin their expectations into eight-hour working days. Therefore, assuming best-case scenario, managers define task deadlines based on their knowledge about task difficulty and employee competences. Incorrect estimation of a deadline results in employees' shirking (i.e. insufficient work intensity or working time) or overworking (i.e. excessive work intensity or working time).

Task performance

Task performance, signifying the diligent performance of role-prescribed activities assigned by the manager during a contracted period of time, is one dimension of a broader concept of work performance. Task performance focuses on the act of working rather than on the outcomes of work.

Inspired by research on performance determinants and contemporary theories of motivated action, we focus on two direct task performance determinants, which are individual characteristics of employees, namely, competence and effort level (McCloy, Campbell, and Cudeck 1994).

In the proposed computational model, competence level is considered broadly as resource of an individual needed for effective task performance. Competence incorporates three domains of educational activities originally described by Benjamin Bloom, namely,

cognitive, affective and psychomotor (Bloom et al. 1956). The three domains became known in training research and practice as the KSA (knowledge, skills and attitudes) approach (Winterton, Delamare-Le Deist, and Stringfellow 2006). Since a body of research indicates that an employee's position in a network influences work performance (Sparrowe et al. 2001), in our conceptualization, the domains were supplemented by social capital – resources embedded in one's social networks, which can be accessed or mobilised through ties in those networks (Lin 2001). The computational model we introduced further assumes a multi-method oriented rationalistic approach to competences, which means that competences are attributes (a characteristic of the rationalistic tradition, opposed to interpretive tradition highlighting that competences are constituted by the meaning the work takes for the worker in his/her experience of it) possessed by workers needed for effective task performance (multi-method oriented approach combining worker- and work-oriented foci; for a review of approaches to the conceptualisation of competences, see Sandberg 1994; Sandberg 2000). The chosen tradition of conceptualising competences is further reflected in the formalisation present in Equation 1. By definition, higher competence levels increase task performance.

The second factor identified as an employee characteristic directly influencing task performance is effort. A large body of research has shown that increasing effort positively affects task performance (e.g. Gardner et al. 1989). Even though motivation is not a subject of this study, and is therefore absent in the computational model, it is important to conceptually clarify the relationship between motivation, effort and task performance. Motivation is a psychological state, while effort is a physical phenomenon. Initially, studies such as Deci's (1971) classic self-determination theory experiments assumed that effort and motive strength are linearly related and measured motivation via exerted effort, i.e. the amount of time subjects spent working on a task. Contemporary approaches, such as motivational intensity theory (MIT, hereafter) which uses psychophysiological indicators, question the linearity of the relationship between the two (Richter, Gendolla, and Wright 2016). MIT studies show that motivation impacts task performance only indirectly, by limiting the maximum level of exerted effort (Wright and Brehm 1989). Since our model investigates structural possibilities for shirking and overworking, rather than utilisation of those possibilities, it assumes a direct relationship between effort and task

performance and does not investigate the role of motivation.

The last factor assumed to influence task performance is difficulty. Studies in the MIT paradigm show that task difficulty provides information about the amount of resources needed to complete the task, and therefore is linearly related to the exerted effort (Richter, Gendolla, and Wright 2016). The computational model assumes task difficulty is characteristic of a task *per se*, not of an individual performing it, although individuals might differ with respect to how they perceive the difficulty of a given task. The model states that the more difficult the task, the more effort is needed to complete it.

The role of informational advantages

The above factors influencing task performance are associated with a certain informational advantage structure. The employee has better knowledge regarding competences and effort exerted during task performance than the manager. However, neither actor knows the true task difficulty beforehand. The first two informational advantages are described using the principal-agent theory.[4] The third one refers to a problem of task uncertainty.

Principal-agent theory (Laffont and Martimort 2002) is an economic theory which refers to the dilemma that arises where one party - 'the principal', relies on another - 'the agent' to act on their behalf, in their best interests. A principle-agent problem arises where the interests of the two parties are not aligned and where they have access to different information. This problem has been the topic of previous research in employment situations where the principal is the employer and the agent the employee (e.g. Biglaiser and Mezzetti 1993; Gershkov and Perry 2012). It has also been applied in a range of other contexts such as project management (Müller and Turner 2005) and natural resource management (Hotte, Mahony, and Nelson 2016). Applying principal-agent theory within an employment relationship assumes that the agent's and principal's goals are conflicting (e.g. the manager wants the employee to exert maximum effort at all times, however, the employee is effort-averse).

Two types of principal-agent problems have been studied: *adverse selection*, i.e. hidden information, and *moral hazard*, i.e. hidden actions (Gaivoronski and Werner 2012; Hart and Holmström 1987). In this paper, we focus on the problem of adverse selection – employee's private information about his true level of competences (Biglaiser and Mezzetti 1993; Gershkov

and Perry 2012) and we investigate how it influences the intensity and time of exerted effort (i.e. the problem of moral hazard). It is worth pointing out that in the context of acquiring employment, low-skilled agents pretend to be highly skilled to receive better terms at the time of contracting. However, the reverse is the case after the contract is signed. It is in the best interest of the employee not to disclose how high his competences are because it lowers his marginal price of labour – he would have to perform more work for the same remuneration.

Task uncertainty is the degree to which tasks are open to chance-based, task-relevant influences (Hirst 1987). In moral hazard, the unpredictability related to employed methods and task performance is represented by the noisy environment influencing outcomes. In practice, managers estimate the time sufficient to accomplish a task of certain difficulty by an employee possessing given competences. However, reality holds an informational advantage over managers and employees, as they merely guess the nature of the task, with its true difficulty and complexity.

Research questions

Previous research on the principal-agent problem shows that possibilities for engaging in shirking stem from the imperfect observability of employee competences, which generates informational advantages on the side of employees. Task uncertainty has also been shown to influence performance (Belkaoui 1990). So far, no study has investigated the impact of those factors by presenting a single, coherent mechanism of task performance. Moreover, past analyses have focussed on presenting a static picture of aberrations in work intensity and working time, even though the latter is immanently a dynamic phenomenon. We address three questions insufficiently answered by the existing scientific literature, namely, how to do:

1. adverse selection,
2. task uncertainty, and
3. interactions between adverse selection and task uncertainty influence the aberrations in work intensity and working time of employees.

Computational model of task performance

To address the research questions, the process of task performance in organisations, utilising theoretical approaches from several disciplines described in the earlier sections, is operationalised in a form of a computational model programmed in an agent-based framework. This particular method was chosen for several reasons. The first reason involves the subject of scientific inquiry. Shirking and overworking are shown as behaviours emerging from decisions of employees, which are influenced by various factors. Computational modelling enables (1) designing a relatively complex formal model in one environment and (2) performing simulations of that model, allowing for systematic variations in the factors of interest. The second reason is related to the knowledge gap about the dynamics of shirking and overworking. Employees in the model gradually achieve excellence in their ability to handle day-to-day work tasks. Introducing a learning function to the model calls for a method that allows for dynamics, where analysing the temporal dimension is easily achieved. Third, the conceptualisation of this work should be considered as building a foundation for further scientific development. Although the model does not currently contain distinctive elements of a traditional agent-based model, e.g. social networks and space, it is possible to include these elements in the future.

The model illustrates an organisation comprised of three employees and a set of tasks available for them to complete (Figure 1). Each employee is characterised by a certain level of competence, enabling him to complete work tasks. Initially, all employees are available for receiving tasks. Once an employee is assigned a work task, a new task of random difficulty is added to the pool, so that ten tasks await assignment at all times. Work tasks vary with respect to difficulty and competence-dependence[5] – a degree to which time for completing a task depends on employee competence. Subsequent parts of this section explain the assumptions of the model regarding task assignment, task completion, and measuring work intensity and working time aberrations. The next section describes simulations of the model in various settings and analysis of the dynamics of shirking and overworking.

Task assignment

The manager, who is not physically present in the model, assigns tasks to individual employees. Based on individual in-depth interviews with a group of managers, two rules of task allocation were identified (Antosz 2018). First, tasks are assigned to available employees. Second, task difficulty corresponds to employee competence level, as it is perceived by the manager. Tasks are appointed starting from the least skilled employee. Such a rule ensures that a more
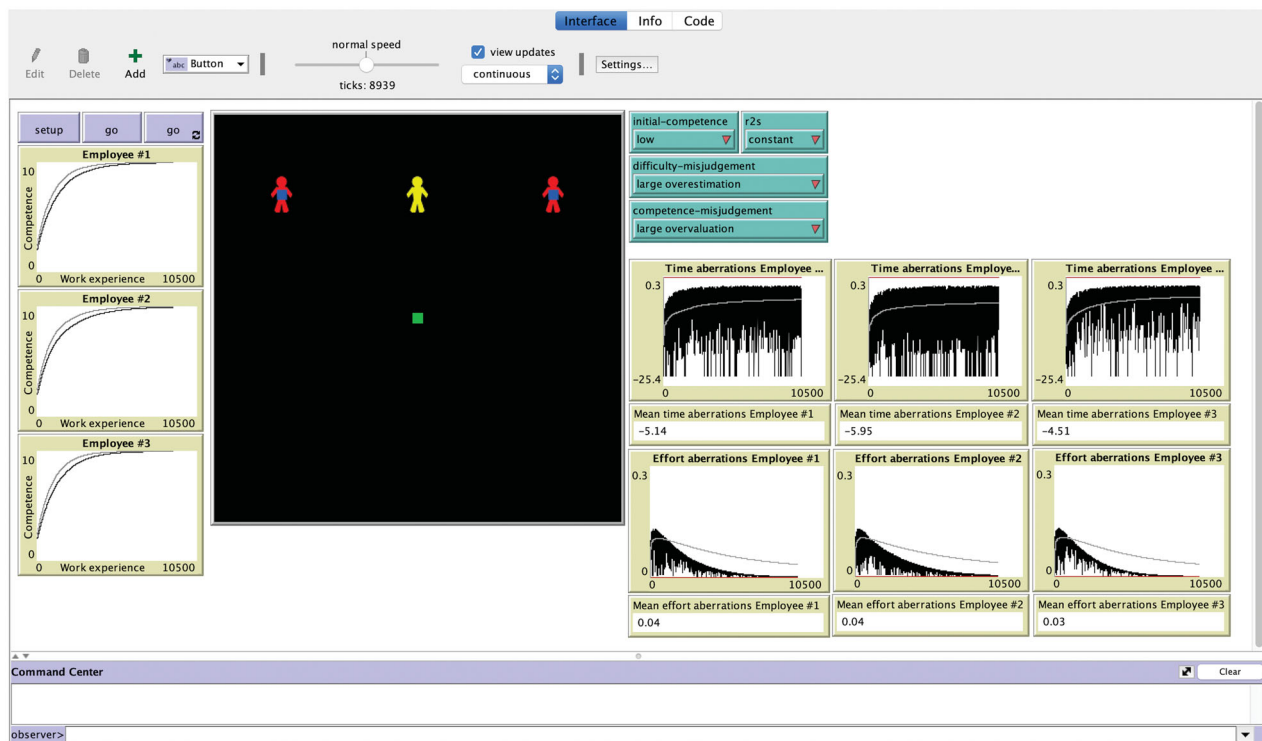
Figure 1. Screenshot of the task performance model in Netlogo interface.

competent employee does not receive an easier task than his less experienced colleague. Once a task is assigned to an employee, a deadline for completion is established. The amount of time required for an employee to complete a task increases with the difficulty of tasks and how time-consuming they are, and decreases with employee effort and competence level. Competence level influences time to the extent that a task is competence-dependent. The manager estimates the amount of time required for accomplishing a task to an acceptable standard by a certain employee based on her perception of employee competence, her perception of task difficulty, and an assumption regarding the amount of effort the employee will exert. Perception misjudgements correspond to adverse selection, task uncertainty and moral hazard. We assume that the time required for performing the task i by employee j is:

$$t_{ij} = \frac{d_i \beta_i}{(1 + \alpha_i c_j) e_{ij}} \qquad (1)$$

where:
d_i – time-consumingness of task i,
β_i – difficulty of task i,
α_i – competence – dependence of task i,
c_j – competence level of employee j (note that the competence of employee j increases after completing each task),

Table 1. Informational advantages present in the computational model.

	Perspective		
	Manager	Employee	Actuality
Competence level	$c_j + \varepsilon_{c_j}$[1]	c_j	c_j
Effort	0.8	e_{ij}	e_{ij}
Task difficulty	$\beta_i + \varepsilon_{\beta_i}$	$\beta_i + \varepsilon_{\beta_i}$	β_i

e_{ij} – effort of employee j performing task i (assumes positive values between 0 and 1).

The degree to which a task is time-consuming is expressed in units of time and was assumed to be constant throughout the simulation (i.e. $d_{ij}=10$ for all i and j). The manager's expectations were set to 0.8 of maximum effort.

Task completion

Once the employee knows the deadline for task completion, he can choose a minimum level of effort, aiming for the task to be accomplished on time. Yet, the employee, just as his manager, might misestimate the actual amount of time needed for task completion, as he does not know the true task difficulty (the effect of task uncertainty). We assume that employee's and manager's perceptions of task difficulty are the same. Table 1 presents the informational advantages implemented in the computational model.

As employees gain experience by performing tasks in the organisation, they increase their competence levels. The rate of this increase depends on the level of already obtained competences. A novice considerably increases his competences with each completed task. As the employee becomes more competent, the same task stimulates a smaller increase in competences, to a point where increase in competences due to performing additional tasks becomes insignificantly small (Minbashian and Earl 2013). Thus, we approximate the employees' learning curve by the hyperbolic tangent, which is a well-known function following the described dynamics. The competence level of employee j (c_j) is expressed as follows:

$$c_j = c_{max} \tanh\left(\frac{E_j}{E_s}\right) \quad (2)$$

where:

c_{max} – maximum competence level,
E_j – work experience of employee j,
E_s – scaling parameter.

The scaling parameter (E_s) determines how fast employees increase their competence levels. Professions involving more complex tasks would be characterised as having higher values of the scaling parameter. Throughout the simulations, the scaling parameter was set to a value of 500. Such a setting assures adequate duration of each performed simulation and, in effect, allows for a sufficiently detailed level of observation.

Note that an increase in experience level does not depend on a task's competence-dependence nor on the level of employee effort. For example, when two equally competent employees perform equally difficult tasks with different levels of effort, their work experience increases by an equal amount. The increase simply takes place faster for the employee exerting a greater amount of effort. Employee work experience is updated based on the true values of employee competence and task difficulty. However, the manager updates her information based on the values of employee competence and task difficulty that she perceives.

The overall experience level of employee j (E_j) is a function of his initial abilities (E_{0j}) and a sum of what he has learned after having performed his first n tasks in the organisation:

$$E_j = E_{0j} + \sum_{i=1}^{n} t_{ij}\alpha_i e_{ij} \quad (3)$$

Employees enter the organisation with different competence levels. The initial experience level of employee j (E_{0j}) is translated into a specific position on the learning curve according to function:

$$\frac{E_{0j}}{E_s} = arctanh\left(\frac{c_j}{c_{max}}\right)$$
$$= \frac{1}{2}\left[ln\left(\left(\frac{c_j}{c_{max}}\right)+1\right)-ln\left(1-\left(\frac{c_j}{c_{max}}\right)\right)\right] \quad (4)$$

where:
$\frac{c_j}{c_{max}}$ – percentage of maximum competence level of employee j.

The simulation ends when the competence level of every employee reaches $0.995\,c_{max}$, an arbitrary cut-off point, which is close to a theoretical (asymptotical) maximum of $c = c_{max} = 10$. Once all employees have mastered performing tasks, they do not learn significantly more after completing additional tasks.

Aberrations in work intensity and working time

Employee's actions can deviate from the manager's expectations regarding exerted effort (work intensity) and working time. Lower/higher than expected levels of effort and time correspond to shirking/overworking. However, the degree of overworking with respect to intensity is limited, as there is an upper limit on effort. The employee can only exert a maximum of 100% of it. Aberrations from the manager's expectations regarding work intensity (aberration of effort, a^e) at each point in time are calculated by subtracting the level of effort expected by the manager from the actual effort exerted by employee j performing task i:

$$a_{ij}^e = e_{ij}^o - e_{ij}^m \quad (5)$$

where:
e_{ij}^o – objective effort exerted by employee j performing task i,
e_{ij}^m – manager's expectations regarding effort exerted by employee j performing task i.

Working time discrepancy manifests as working for an inadequate amount of time. Devoting less time for work than expected is defined here as shirking with respect to time – a situation, when an employee finishes a task earlier but waits until the deadline to deliver it. A contrary situation, in which the employee works more time than he was expected to, comprises overwork with respect to time. It is assumed that the manager abides by the law and expects a maximum of legally defined working time from the employee. Aberrations from the manager's expectations regarding the amount of working time (aberration of time, a^t) are expressed as a percentage of working time expected by the manager, which is spent shirking or overworking:

$$a_{ij}^{t} = 100 \frac{t_{ij}^{o} - t_{ij}^{m}}{t_{ij}^{m}} \%, \qquad (6)$$

where:

t_{ij}^{o}– objective working time of employee j performing task i,

t_{ij}^{m} – manager's expectations regarding working time of employee j performing task i.

Results

The simulations were performed in the *BehaviorSpace* of *Netlogo 5.3.1*, an integrated tool, which allows for performing experiments with the computational model. All the tested factors, in addition to their categories and respective values, are presented in Table 2. The design space of these ($3 \times 5 \times 5$) yielded 75 tested conditions – unique combinations of factor levels, which sufficiently covered the parameter space of the model. *BahaviorSpace* systematically runs each combination of factors 10 times, recording the values of the dependent variables at every time step of the simulation.

Table 2. Factors tested in the simulation.

Factor	Category label	Value
Initial competence level	Low	2
	Medium	5
	High	8
Task difficulty misjudgement (ε_{β_i})	Large overestimation	0.3 β_i
	Small overestimation	0.1 β_i
	True estimation	0
	Small underestimation	−0.1 β_i
	Large underestimation	−0.3 β_i
Initial competence misjudgement (ε_{c_j})	Large overvaluation	0.2 c_j
	Small overvaluation	0.1 c_j
	True valuation	0
	Small undervaluation	−0.1 c_j
	Large undervaluation	−0.2 c_j

As the model is mainly focussed on determining how informational advantages influence shirking/overworking behaviour, the control condition in the experimental design was defined by a true estimate of initial competence misjudgement and a true estimate of task difficulty. As expected, in the control condition, no aberrations of time or effort occur, independently of the initial competence level of employees.

Impact of adverse selection

The simulations show that when task difficulty is estimated correctly, the manager's incorrect evaluation of an employee's competences directly affects the level of invested effort, but not the amount of time it takes to complete a task. As anticipated by the principal-agent theory, undervaluing employee competences generates opportunities to shirk. On the other hand, a belief that the employee is more competent than he actually is results in a necessity for him to overwork in order to complete a task on time. Naturally, similar misjudgement (expressed as a percent of employee competence level) generates larger aberrations of effort for higher initial competence levels.

The effects of adverse selection on exerted effort are only temporary, which is not predicted by the principal-agent theory. As time goes by and employees gain proficiency in completing daily tasks, their informational advantage decreases. Figure 2, presenting the dynamics of effort aberrations, seems to superficially suggest that employees learn to correctly estimate the amount of effort needed to perform a task. This is not the case. Rather, during an employee's career in the organisation, the manager learns to estimate the competences of her subordinate better and is, therefore, able to set more realistic deadlines for performed tasks. Higher values of initial competence

Figure 2. Dynamics of work intensity (work quality) aberrations depending on initial competence misjudgement, and employee's initial competence level. Task difficulty misjudgement = true estimation.
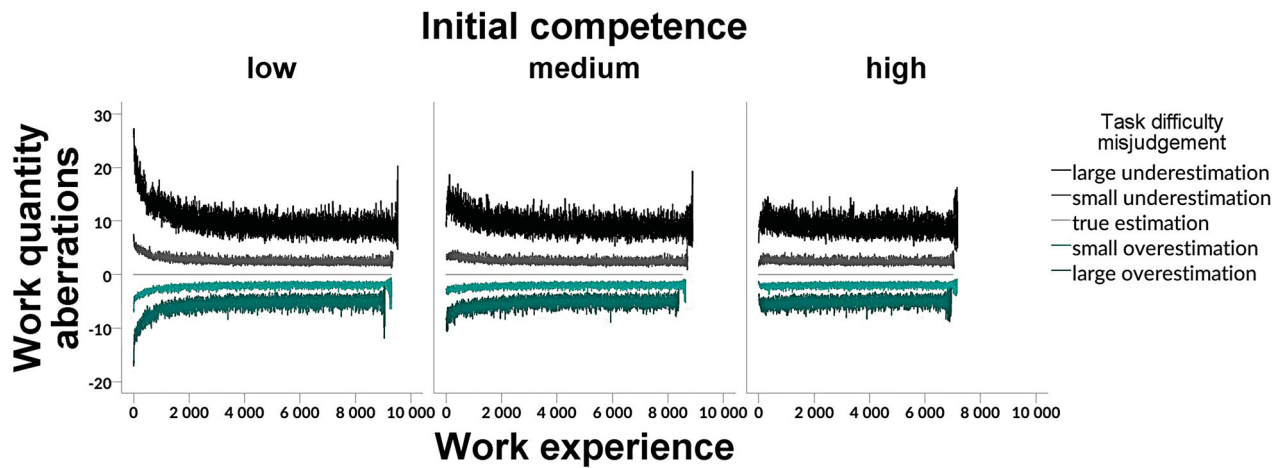
Initial competence

Figure 3. Dynamics of working time (work quantity) aberrations depending on task difficulty, misjudgement, and employee's initial competence level. Initial competence misjudgement = true estimation.

misjudgement result in a longer time needed for the discrepancy between perceived and actual competences to disappear.

Impact of task uncertainty

In comparison to adverse selection, the simulations suggest that the relationship between task uncertainty and work aberrations is more complex. Generally, underestimating task difficulty by either actor leads to a necessity to work longer than expected by the manager. On the contrary, overestimating task difficulty generates opportunities for employees to shirk (Figure 3). Yet, this relationship is not symmetric, as was the case of the impact of adverse selection. A small underestimation (10% of task difficulty) results in employees working for approx. 2.5% more than their manager expects. A large underestimation (30% of task difficulty) leads to working for approximately 10% more than expected. For small (10%) and large (30%) overestimation, the values are significantly lower - 2 and 5%, respectively. The asymmetry stems from the way, in which working time aberrations are measured in the model. Namely, the discrepancy between actual and expected working time is expressed as a percentage of expected working time (Equation 6). *Ceteris paribus*, in case of overestimating task difficulty the expected working time (i.e. denominator) is higher, and the difference between actual and expected working time (i.e. numerator) makes up a smaller fraction. Task difficulty misjudgement operates differently than competence misjudgement, as misestimating task difficulty causes more extreme values of time aberrations, the lower the competences in the beginning of the organisational career. As employees become more experienced, the effect of the initial competence level

diminishes. Competence misjudgement, on the other hand, causes a stronger effect when employees initially have higher competences.

Interestingly, task uncertainty has a profound effect not only on working time aberrations but also on the manager's perception of her subordinates' competences. Through that mechanism, it affects the level of effort aberrations. Even without initial competence misjudgement, by overestimating task difficulty alone, the manager believes that completing a task causes a higher increase in competence than it does in reality, thus requiring the employee to exert more effort than expected combined with finishing the task earlier than expected. On the contrary, believing that the task is easier than it is creates an *even a fool can do that* attitude, where the manager underestimates competence development of her subordinates. The employees, whose perceptions are also biased by task uncertainty, underestimate the task difficulty and initially shirk with respect to work intensity (i.e. *even a fool could do that*). Over time, however, they realise that the task is more difficult than expected, and have to work overtime to finish it before the deadline. Even as employees reach proficiency, a mismatch between what their competences actually are and how the manager perceives them persists. Figure 4 shows the effects of over- and under-estimating task difficulty on work intensity, competence misjudgement and working time.

Adverse selection and task uncertainty interaction

Overestimating task difficulty prolongs the effect of initially overestimating employee competences on adverse selection. The manager overestimates the competences of her subordinates for a longer time,
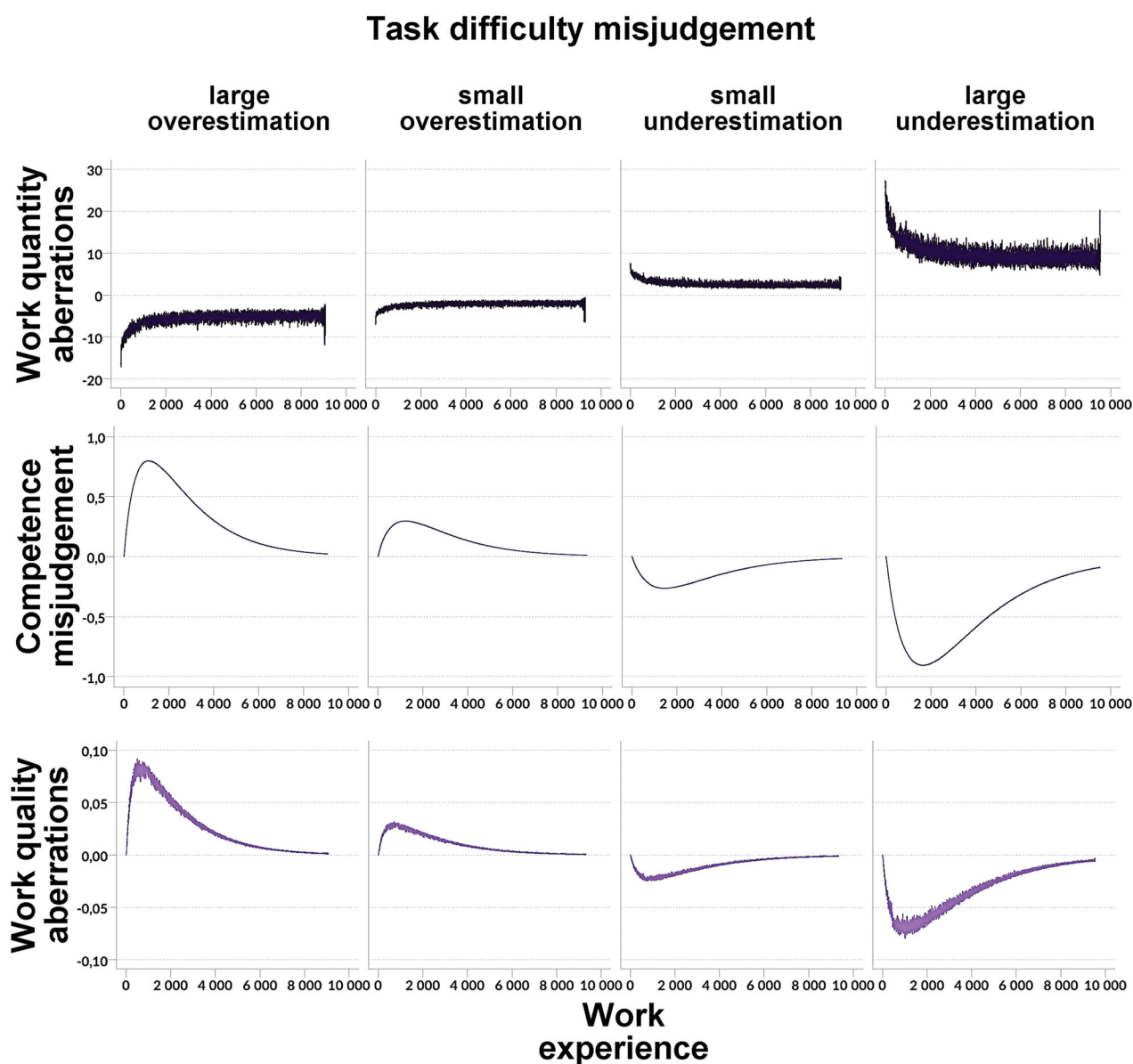
Task difficulty misjudgement

Figure 4. Dynamics of work intensity (work quality), working time (work quantity), and competence misjudgement depending on task difficulty misjudgement. Initial competence level = low, Initial competence misjudgement = true estimation.

compared to when no task uncertainty occurs. Such overestimation results in lengthening the duration of overworking with respect to effort and causes shirking with respect to working time. Similarly, underestimating task difficulty prolongs the effect of initial undervaluing employee competences on competence misjudgement.

In the cases where perception errors are opposite for managers and employees, initial competence misjudgement compensates for task difficulty misjudgement only to a small degree. In rare cases, large misevaluation of employee competences at initialisation (by 20%) decreases the effect of small misestimations of task difficulties (by 10%) on competence

misjudgement, so that the manager does not end up making two opposite judgement errors throughout the employee's career (e.g. initially overvaluing employee competences and, over time, undervaluing them). Minor misestimations of task difficulty prohibit the manager from discovering the true levels of employee competences even after the employee has gained proficiency. We also observe that overestimating task difficulty leads to smaller informational advantages regarding competences, compared to underestimating them. This finding is a consequence of the asymmetry in the effects of task difficulty misjudgement, which was described at the beginning of the previous section.

Conclusions

Shirking and overworking can have negative consequences for both individual employees and the organisation providing employment. Studies show that the most popular activities employees engage in, instead of performing work tasks, include: browsing the Internet for personal use (anything from receiving emails to online games or gambling), socialising with co-workers and conducting personal business (Carroll 2007; Poppick 2016; Salary.com 2014[6]). However, in real life, employees also have far more imaginative ways of spending time at work. In a survey for Careerbuilder.com, 2138 hiring managers and HR personnel shared some stories. Actual examples included blowing bubbles in sub-zero weather to see if the bubbles would freeze and break, shaving legs in the women's restroom, claiming to be praying while sleeping or warming bare feet under a hand dryer. David Bolchover (2005) offers even more graphic examples such as using drugs or having sex with work colleagues. Detrimental effects of such behaviours on employee motivation and productivity are easy to imagine. Excessively long working hours negatively impact employees' health (e.g. cause disturbed sleeping patterns, increased incidence of cardiovascular disease, gastrointestinal and reproductive disorders, musculoskeletal disorders, chronic infections, mental health illnesses; Afonso, Fonseca, and Pires 2017; Tucker and Folkard 2012), their job performance (e.g. burnout, occupational accidents; Tokuda et al. 2009), and family/social life (Fagan et al. 2012). In extreme cases, consequences are fatal. In Japan, where working long hours is relatively frequent, phenomena of *karoshi*, i.e. sudden death due to overworking, usually a direct result of acute cardiovascular events such as stroke and *karojisatsu*, i.e. suicide due to overwork, are recognised (Hiyama and Yoshihara 2008).

Numerous theories highlight that task performance is decreased due to conflicts between employees and their supervisors. While shirking and overworking can certainly be the effects of power struggles involving demotivated employees or overdemanding managers, studies suggest that it is often not the case (Paulsen 2014). We presented a computational model to answer a deeply sociological question, namely, can the structure of work organisation, in combination with adverse selection and task uncertainty, generate opportunities for unintended functions, i.e. shirking and overworking (Merton 1996). Our model, ascribing no ill will to any of the involved actors, shows that these phenomena can occur in any type of work contracted on the basis of working time, when the specific organisation of

work depicted by the computational model takes place, i.e. components such as employees, manager, tasks, deadlines, etc., and operations such as assigning tasks, completing tasks, etc. are present. Contrary to initial intuitions, the model is not only applicable in the contexts of blue-collar work. Even though more flexible work arrangements are gaining popularity (e.g. task-based contracts, where working time is not a concern), the majority of employees in the western world are still contracted for working time (Katz and Krueger 2016; Ter Weel et al. 2018). Moreover, principals of project work are becoming ever present – nowadays even doctors often have 15-minute deadlines per patient visit. All of the interviewed managers and lower level employees, whose stories helped in specifying the assumptions of the computational model, were white-collar workers, including doctors, lawyers and programmers (Antosz and Verhagen 2020). In this context, it is important to remember that the results of the simulations should be interpreted as acceptable possibilities within the system. Situation runs illustrate maximum levels of shirking of an employee, whose unaware manager is satisfied with work performance, or maximum levels of overworking due to a manager, who, to the best of her knowledge, had no intentions of delegating overtime.

With respect to adverse selection, the simulations mirror the predictions of principal-agent theory (e.g. Hart and Holmström 1987) and generate new plausible hypotheses. The results show that undervaluing employee competences generates opportunities to shirk. The larger the undervaluation, the greater the intensity of opportunistic behaviour. On the other hand, a belief that the employee is more competent than he actually is results in a necessity for him to work harder than assumed by his manager in order to complete a task on time. New hypotheses predict that adverse selection affects primarily one dimension of aberrations from managerial expectations, i.e. aberrations of effort. Moreover, the effects of adverse selection are only temporary – as the employees gain experience, the managers learn their true abilities.

Our research shows that task uncertainty is a very serious source of aberrations from managerial expectations, as it impacts both working time and, indirectly, employee effort. Interestingly, if task difficulty misjudgement is of equal level but in the opposite direction, overworking is more severe than shirking. This finding portrays actors' perception of time. For example, let us consider a task that objectively requires two days to finish. In the first scenario, the manager overestimates the difficulty of the task and

sets the deadline for three days. In the second scenario, she/he underestimates it and sets the deadline for one day. Assuming the employee informs the manager about completing a task immediately (after two days), in the first case, he/she only decreased the time of completion by 33%. In the second case, it took him/her twice as long as it was expected. Such a setup results in managers experiencing poor performance as unproportionally exaggerated, compared to superior performance. Another unanticipated result is that task uncertainty can create an effect of adverse selection (employee informational advantages regarding competence levels). Misestimating task difficulty leads to the manager misestimating the increase in employee competences, which in turn affects the effort aberrations. Moreover, the asymmetry of the effects of opposite directions of task uncertainty influences the level of informational advantages. Specifically, overestimating task difficulty leads to smaller informational advantages regarding competences, compared to underestimating them.

Limitations and further developments

Conceptualising models always entails a trade-off between simplicity and applicability to real-life situations. Therefore, several decisions were made to reduce complexity and achieve the primary purpose of the model. Those decisions limit the scope of the model and further applicability of its results. This model should, therefore, be regarded as an ideal type (Weber 1949) or a typification (Boero and Squazzoni 2005).

The proposed mechanism is limited to the structural origin of shirking and overworking. It is debateable to what extent techniques, which are detached from real-life data, can offer reliable estimates of phenomena. Computational modelling belongs to a group of *in silico* techniques, which allow for perfect control of all confounding factors. It must be emphasised that in real life, on top of structural, other factors influence the level of shirking and overworking. The impossibility of including all of them even in the most rigorously controlled experiment points to the challenge of verifying model validity. However, to cite the classic, *the most that can be expected from any model is that it can supply a useful approximation to reality: all models are wrong; some models are useful* (Box, Hunter, and Hunter 2005; 440). Hopefully, this model is, in fact, useful in making attempts to estimate the possibilities of shirking and overworking, which stem from the structure of the work process in organisations. Even

though no quantitative empirical data was used to validate the predictions of the model, it does not mean that the model is completely unvalidated. The existence of certain independent variables, the relationships across and between these variables, as well as the concept of shirking and overworking are strongly rooted in theoretical approaches (e.g. principal-agent theory) and empirical data (e.g. Antosz 2018; Antosz and Verhagen 2020). This supports the concept and criterion validity of the model's underlying assumptions. Also, the fact that some simulation results are consistent with predictions occurring in other studies (e.g. Hart and Holmström 1987) strengthens the validity of the proposed mechanism.

Naturally, the presented computational model can become a foundation for further scientific advancements. Future directions for development include, for example, introducing interactions among employees. In-depth interviews (Antosz 2018; Antosz and Verhagen 2020) suggest that employees increase their competence levels through interacting with others and use social learning to estimate the acceptable levels of shirking and overworking in their workplace. Another increase in model complexity entails introducing heterogeneity with respect to task uncertainty. There are two distinctive groups of managers, who differ in their personal experience of performing the same work tasks as their subordinates (Antosz 2018; Antosz and Verhagen 2020). Managers who previously performed the same work tasks as their now-subordinates are less prone to task uncertainty than managers, who have not. Introducing trust and reputation is another attractive direction for further model development. Employees, whose violation of organisational norms regarding shirking is detected by co-workers, could be punished by the means of decreasing their reputation. This direction is especially interesting because reputation has previously been treated as a tool for social control in computational models (Hales 2002). Lastly, several studies suggest that in some settings competences negatively impact effort (Szumowska, Szwed, Kossowska and Wright 2017). Yet, as both competences and effort positively affect task performance, the more subtle, direct relationship between them is cancelled out and therefore, difficult to observe in experimental settings. Computational modelling and simulation, allowing for more scrutiny in controlling the possible complex relationship between independent variables, could shed light on that relationship. Last but not the least, to shed light on strategies combating overworking among employees, future directions also include

building models based on occupational stress and workload management approaches, such as the job demands-resources model.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes

1. The motivation to focus on inputs, rather than outputs of labour stems from the fact that quality of work products is not a simple function of resources invested by the employee (Alchian and Demsetz 1972).
2. For a more complete analysis, please see Antosz and Verhagen 2020.
3. For simplicity, work tasks are assumed to be completed when they comply with the quality standards held by the manager.
4. Other important theoretical frameworks used to study the phenomenon of shirking in the labour market include inspection games (Dresher 1962) and efficiency wages (Shapiro and Stiglitz 1984). For a comparison of these approaches, see Antosz 2018.
5. Competence-dependence on its own does not influence the amount of time required for task completion, it only does so in combination with employee competence level. Low values of competence-dependence indicate that increased competences do not decrease the time of completing a task significantly. Difficulty and competence-dependence are assumed to be positively related, i.e. the more skills required to complete a task within a certain period of time, the more difficult that task.
6. For a comparative review of the survey results, see Antosz 2018.

Funding

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